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ABSTRACT

Designed to accompany a 30-minute seminar televised over the Cable Satellite Public Affairs Network (C-SPAN), this handbook contains 4 readings on energy for high school students. Following an introduction on energy policy formulation, the first selection outlines the role of nuclear energy in America's future. Included are insets on the operation of a nuclear power plant and a review of the 1979 events at Three Mile Island. The second reading discusses the environmental repercussions of various types of energy use, including oil, natural gas, coal, and synthetics. The third reading presents the case for renewable forms of energy such as wind, hydroelectric, and geothermal power, while the final selection discusses the global energy picture and the geopolitics of energy. Each reading concludes with a mini-debate on a key issue, for example, the pros and cons of nuclear power; the practicality of synthetic fuels, and the pros and cons of global energy interdependence. All selections are supplemented by charts, graphs, and illustrations. (LP)

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Close Up Special Focus: Energy

Written by
Fritz Mayer and Bruce James
with Bruce W. Jentleson

CloseUp

Close Up Telecommunications and Publications

Since 1979 the Close Up Foundation, a Washington-based government studies program, has been providing schools and communities with the opportunity to participate in a CLOSE UP view of government through four televised series carried on the Cable-Satellite Public Affairs Network (C-SPAN).

The 30-minute televised seminars, funded by Conoco Inc. and R.J. Reynolds Industries, Inc., feature high school participants in the Washington program questioning key policymakers in lively discussions about important issues.

The Close Up Foundation also publishes print materials to be used with the televised seminars. Together, the print and video materials form a curriculum package that can enhance classroom learning.

One of the mini-series in the program schedule is *Close Up Special Focus on Energy*. This publication has been designed to be used with the televised energy series. Also available is a curriculum guide.

For more information about Close Up televised seminars and related publications, please contact the Close Up Foundation, 1235 Jefferson Davis Highway, Arlington, Virginia 22202.

CLOSE UP PUBLICATIONS
Editor Fritz Mayer
Editorial Staff Bruce W. Jentleson, Bruce James, Jacqueline Hess, Kathie Janger, Steven Waxman
Production Bob Walker
Distribution Shirley McDermott

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Introduction: Making Energy Policy

The American lifestyle depends on energy. An automobile, for example, not only requires considerable energy to operate, but also takes energy to build. Iron ore and bauxite are mined and processed into steel and aluminum. Metal is shaped into parts. Parts are assembled into cars. Cars are transported by train and truck to showrooms across the country. Every step requires energy. Before the first gallon goes into the gas tank, every car has already consumed considerable energy.

A T-bone steak, like a car, is the culmination of another long chain of energy inputs. Ground is broken, seed sown, fertilizer and water applied. The sun's energy turns seed to grain. The crop is harvested. Cattle are fattened and transported to slaughterhouses. Beef is transported in refrigerated trucks to markets, cut into steaks by electric machines, packaged in plastic (a by-product of oil), and displayed in refrigerated cases. Finally, of course, we use gas, electricity or charcoal to cook the steak.

The same pattern holds true for virtually every aspect of American life. The appliances in our kitchen, the devices that heat and cool our homes, the buildings in which we live and work, the food we eat. All take energy to use and energy to make. Energy is the lifeblood of America.

Energy as an Issue

Despite the current importance of energy, however, energy issues did not play much of a role in American politics before 1973. The *Congressional Quarterly Almanac*, which provides a comprehensive summary of legislative activity, did not even include "energy policy" in its table of contents until 1973. But the Arab Oil Embargo of 1973, and the shortages and high prices it caused, brought energy abruptly into the national spotlight. A series of lesser "crises" — the natural gas shortages during the winters of 1975/76 and 1976/77, the coal shortage during the winter of 1978/79 (caused by the longest coalminers' strike in history), the paralysis of the nuclear industry by the near-disaster at Three Mile Island in 1979 — all served to focus attention on energy. By the end of the 1970s, energy issues had risen from a position of minor importance to the top of our agenda for the new decade.

To many Americans, the crises now seem to be far in the past, but energy problems are still a long way from resolution. In large part, it has been difficult to reach a consensus on energy policy because of a fundamental disagreement about the role government should play in the field of energy. Some believe decisions about energy production and consumption should be made in the marketplace. These free market advocates believe that government intervention causes inefficiency, and that the public interest is best served by the free market. Others believe that left to itself, the market will not result in production and consumption patterns beneficial to the public. They argue that there is no free market, and that if government does not intervene in the marketplace, only the interests of the controlling forces of the market will be served, and not the interests of the people.

Forms of Government Involvement

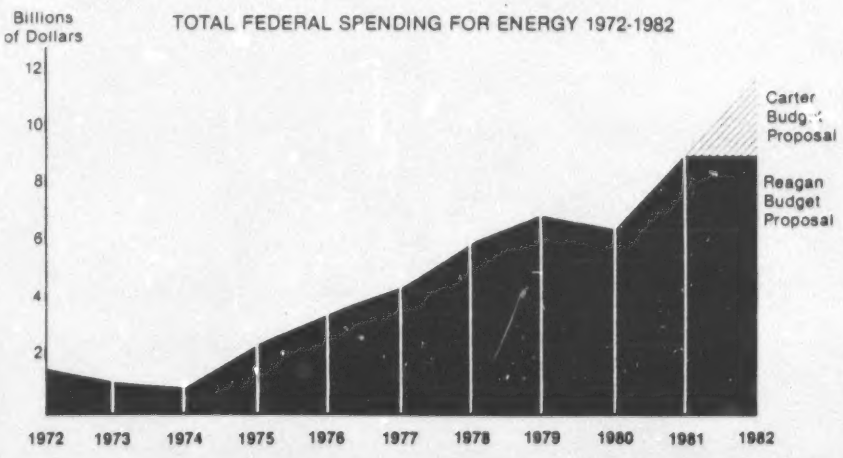
Government involvement in energy production takes many forms. Some policies regulate prices to encourage or discourage consumption or production of certain fuels, or to keep prices down to protect consumers. Price controls on natural gas, for example, save consumers millions of dollars. However, they also have the effect of encouraging consumption and discouraging production, two reasons why former president Carter lifted controls on oil.

Other policies affect consumption directly, either by rationing the amount of energy available or by controlling its end use. Fuel efficiency standards for cars, the 55 mph speed limit, and regulations setting federal office building thermostats at 68° in the winter all exemplify direct government action to control end use of energy.

Research and development of new technologies are also often funded by government. Research and development of nuclear energy technology, for example, have been funded almost completely by the federal government. Without this support it is doubtful that commercial nuclear reactors would have ever been possible. The government has also invested in research and development of solar and other renewable sources, although at a much lower level.

Government involvement also takes the form of incentives to produce. These may be low-interest loans, loan guarantees, purchase agreements or price guarantees, all of which are intended to encourage the development of new productive capacity. The Synthetic Fuels Corporation, established in 1980 to encourage the development

TOTAL FEDERAL SPENDING FOR ENERGY 1972-1982



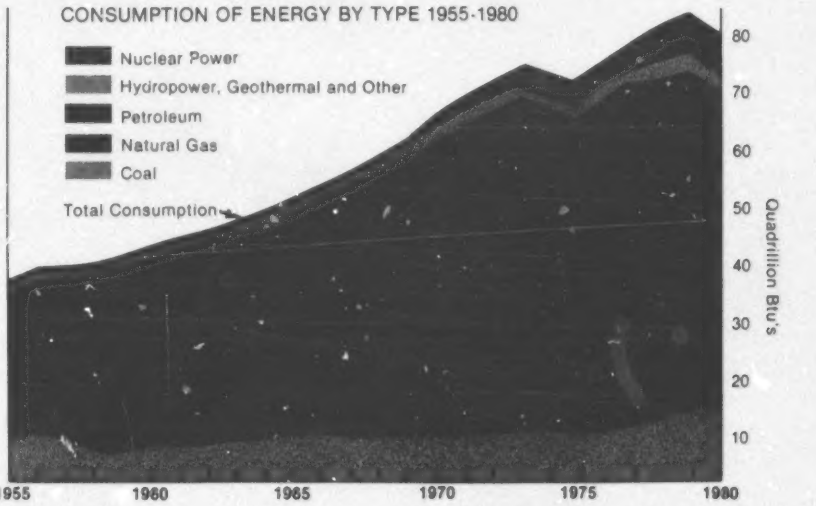
of synthetic fuels, is a classic example of government production incentives. It provides loan guarantees, low-interest loans, and other forms of support to companies that build plants to produce synthetic fuel.

Environmental regulation is probably the most controversial form of government intervention in the marketplace. Environmental regulations are intended to limit the damage to the environment caused by energy production or consumption. They are controversial because they often cost money and therefore raise the cost of producing and consuming energy. Regulations on strip mining coal, for example, require coal companies to repair the land they tear up while mining. The regulations protect the environment but also increase the operating costs of coal companies. Regulations on burning coal require factories to install expensive scrubbers to remove pollutants from smoke.

Finally, the government may intervene to cushion the economic impact of other policies, particularly if they result in higher prices for consumers. After oil prices were decontrolled in 1979, for example, energy assistance programs were instituted to help poorer people pay the higher prices.

The Department of Energy

The Department of Energy carries out most of the federal government's activities in the field of energy. Since its creation in 1977, the Department of Energy has received a tremendous amount of criticism. Many, including President Reagan, have advocated abolishing it altogether. Obviously, were it abolished, many of its functions would be carried out by other departments, but the debate over the existence of the department reveals a sharp difference of philosophy between its attackers and its defenders. Opponents of the Department of Energy also generally advocate a limited government role in the area of energy. They believe that in most cases energy production and consumption patterns should be determined by the marketplace. Supporters of the Department of Energy (who may also criticize the way it is actually run) tend to believe government should play a major role in the area of energy. They believe that the market does not always function in the public interest, and that production and consumption patterns beneficial to the public should be encouraged by government actions.

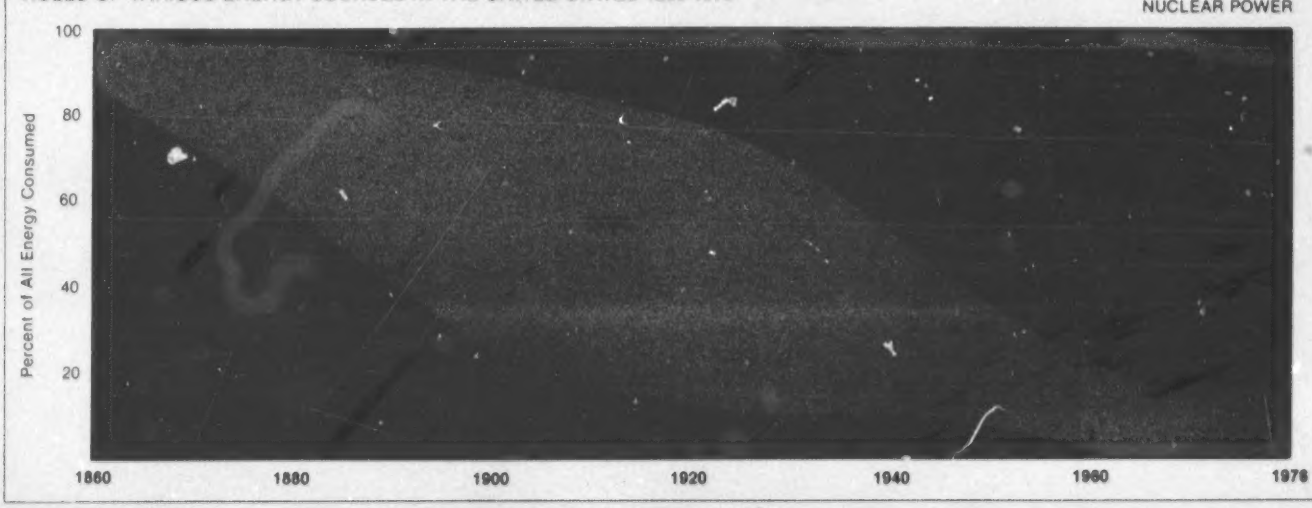


The Proper Role of Government

In practice, few legislators advocate either a pure free market or total government control. Although they may oppose certain forms of government intervention, supporters of the energy industry may favor government support for research and development, or production incentives in the form of price guarantees for synthetic fuels. Environmentalists tend to favor government intervention in the form of environmental regulations, but in the case of nuclear power they may want the government to abandon its support and force nuclear power to compete on the open market. For most legislators, the key questions are not simply whether or not government should intervene in the marketplace, but, rather, when, in what form, and to what extent it should intervene.

In the chapters that follow, the same questions will appear again and again. For nuclear power, the balance between energy and the environment, renewable energy and the global energy scene, the questions are not only what decisions should be made, but also who should make them.

ROLES OF VARIOUS ENERGY SOURCES IN THE UNITED STATES 1860-1976



Nuclear Energy in America's Future

Probably no other single subject in the field of energy has generated as much controversy as the future of nuclear power has. Supporters of nuclear energy consider it a safe, clean and cost-effective solution to many of America's energy problems. Opponents of nuclear energy are equally convinced that it is unsafe, environmentally hazardous and economically unsound. Since the accident at the Three Mile Island nuclear power plant in 1979, the future of nuclear energy has been a topic of much public discussion in America. The question is simple: Should the United States develop nuclear energy as a substitute for its present energy supplies?

Today there are 74 nuclear power plants operating in the United States. In 1980 they supplied approximately 10.6 percent of the total electricity produced in America, down from a peak of 12.5 percent in 1978. Also decreasing is the number of reactors planned for the future. In 1975, 236 reactors were either built or on the drawing boards. Now the total is only 176. This slowdown in the development of nuclear power reflects the way in which the future of nuclear energy has gone from bright to cloudy. At one time, optimists had so much confidence in nuclear power that they said it would someday provide electricity so cheaply that we would give it away. Today, a number of major problems threaten to halt the development of nuclear power altogether.

Safety

One of the most important issues facing nuclear power is the issue of safety. The nuclear material used in a reactor is very dangerous and must be shielded from the outside environment. Should an accident result in the release of this material into the air or water, thousands of lives could be lost. The Rasmussen study, the most comprehensive analysis of the safety of nuclear power, estimated that a "most serious" nuclear accident — the worst possible case — could kill more than 3,000 people, cause cancer in many thousands more, and do billions of dollars worth of property damage. The study also concluded, however, that the likelihood of such a serious accident was extremely low. It calculated that assuming 100 nuclear plants were in operation, this kind of accident should occur only once in 10,000,000 years. Critics of nuclear power say these figures are unrealistically low.

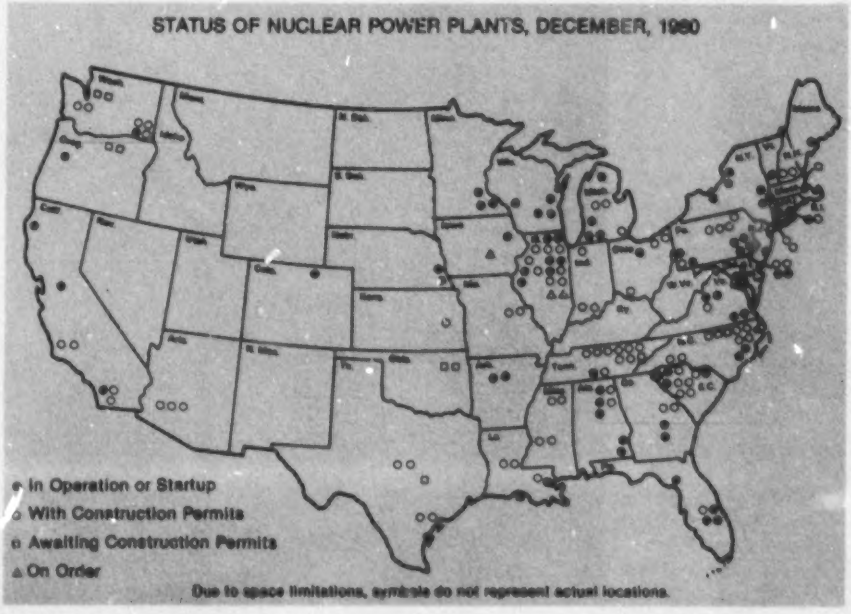
Due to the hazardous nature of nuclear energy, nuclear power plants have been built with many safeguards. Nuclear industry spokesmen call nuclear energy an extremely safe form of energy. They cite the fact that to date nobody has been killed by the operation of a nuclear power plant. They say the risk of death from a nuclear accident is very slim, less than the chance of being hit by lightning. Nuclear critics argue that although the record for nuclear power has been good so far, even one serious accident would be catastrophic. They point to lesser accidents such as the one at Three Mile Island as evidence that the possibility of an accident is greater than the nuclear industry acknowledges.

Unlike other major industries, the nuclear industry is not fully insured. Because private insurance companies were unwilling to insure nuclear power plants, Congress passed the Price-Anderson Act in 1957 to limit the liability of the nuclear industry should an accident occur. Opponents of nuclear power cite the Price-Anderson Act as evidence that nuclear power is too hazardous. Supporters argue that the nuclear industry has been unable to obtain private insurance only because the insurance industry would not have sufficient assets to cover the damages of a major nuclear accident, and not because of the chances of that happening.

Nuclear Wastes

Nuclear power plants do not pollute the environment in the ways we normally think of pollution. In normal operation, they emit tiny amounts of radiation and hot water — no smoke, soot or carbon dioxide. However, this does not mean nuclear power is without its environmental problems.

Every year a nuclear power plant creates about a ton of highly radioactive spent fuel, which must be prevented from entering the environment. Radioactivity can have a number of harmful effects. High levels can cause nausea, burns, cancer, genetic damage and death. Lower levels have also been linked to cancer, but this connection is much harder to


STATUS OF NUCLEAR POWER PLANTS, DECEMBER, 1980
● In Operation or Startup
○ With Construction Permits
▫ Awaiting Construction Permits
△ On Order
Due to space limitations, symbols do not represent actual locations.

establish. There is considerable dispute as to what constitutes a safe level of radioactivity.

Nuclear wastes are not only dangerous, but they remain that way for a long time. Plutonium, one of the elements contained in spent fuel, has a half-life of 24,000 years, which means that in 24,000 years plutonium will still be half as radioactive as it is today. The longevity of nuclear wastes concerns many critics, who say no government can ensure the safety of anything for such long periods of time, and who question the morality of bequeathing such dangerous materials to future generations.

At the moment, nuclear wastes are being stored in temporary containers in ponds near reactor sites, pending decisions about permanent storage. Since these decisions have been repeatedly delayed, the temporary storage sites are beginning to reach their capacity. A decision must be made in the near future. The most commonly discussed method for permanent storage is to solidify the waste by mixing it with molten glass, to place the solid waste in containers, and to bury these containers in some geologically stable place, perhaps in abandoned salt mines. But the problem of agreeing on a permanent solution seems to be getting more and more difficult. Although the solid waste will not leak out of its containers and contaminate ground water and soil, it is much more radioactive than liquid waste. Nobody wants these materials near where they live. Local opposition has arisen in many areas of the country. Twenty states now have laws that prohibit or limit nuclear waste disposal.

Reprocessing

The nuclear industry would prefer that the spent fuel be reprocessed before being placed in permanent storage. Reprocessing would remove still useful materials (mostly uranium and plutonium) from the spent fuel for reuse in reactors and would concentrate the waste materials, significantly reducing the amount of waste that must be disposed of. However, there is considerable opposition to licensing nuclear fuel reprocessing plants in the United States. The primary reason is that plutonium reprocessed from spent fuel would be attractive to nuclear terrorists, who might steal the plutonium to make a bomb. For this reason, Presidents Carter and Ford refused to license reprocessing plants. However, President Reagan has since lifted the moratorium on reprocessing plants.

Decommissioning

Another problem related to the disposal of spent fuel is what to do with the power plant itself when it wears out. Most nuclear reactors are designed to operate for a period of 30 years. After that, they begin to wear out, and the danger of an accident increases. Unlike conventional power plants, however, a nuclear plant cannot simply be demolished. After years of contact with the radioactive material, reactor walls and pipes in the plant become radioactive themselves. Eventually, the plant must be taken apart piece by piece and the parts disposed of in much the same way as spent fuel.

This is likely to be a very expensive process. Cost estimates for decommissioning start at $100 million, but they are hard to estimate since no major power plant has yet been decommissioned. If Three Mile Island is not reactivated, it may be the first large plant to be decommissioned.

Economics of Nuclear Power

At one time, nuclear power seemed to promise virtually free electricity. That has not proved to be the case, but nuclear energy may still have a cost advantage over coal and oil. Although nuclear power plants cost more to build than conventional power plants, uranium costs less than coal and much less than oil. Industry spokesmen point to this last advantage as an argument for moving forward with the development of nuclear energy. They claim that nuclear plants

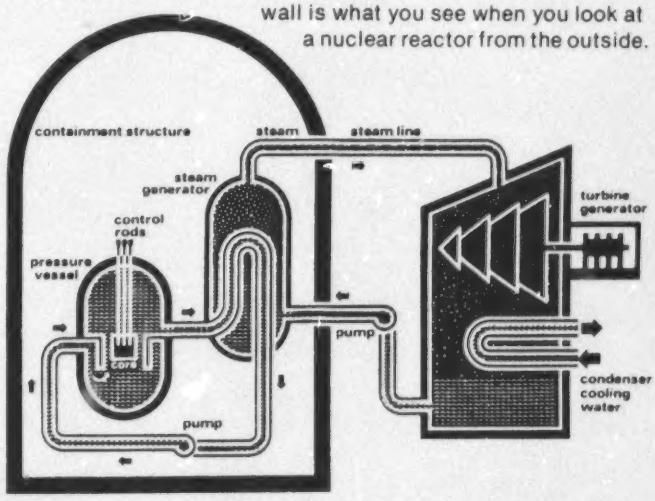
How a Nuclear Power Plant Works

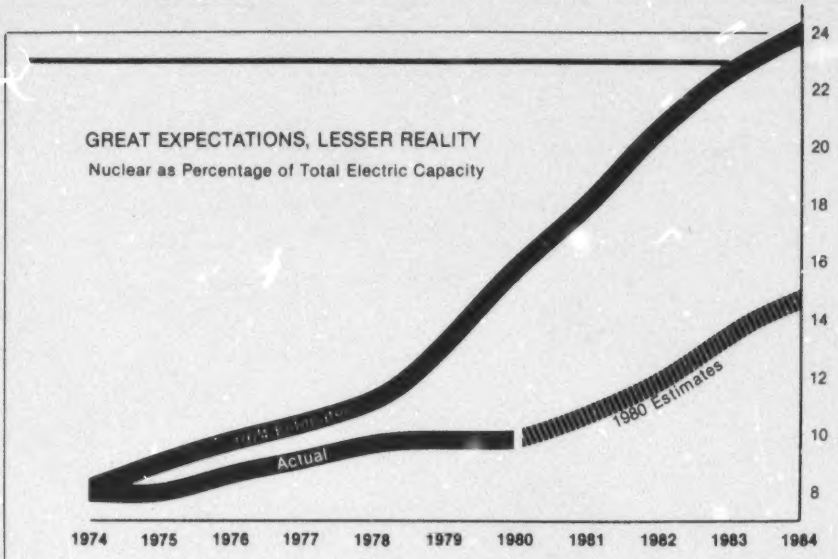
Nuclear energy is only used to produce electricity. Nuclear power plants use uranium rather than coal or oil as fuel. But unlike coal- or oil-fired plants, nuclear plants do not burn their fuel. Instead, they produce heat by nuclear fission, the splitting of the nuclei of uranium atoms. When a uranium nucleus is split, it releases a tremendous amount of energy, as well as free neutrons traveling at high speeds. These neutrons collide with other uranium nuclei, splitting them and causing a chain reaction. This reaction produces an enormous amount of heat. In a nuclear power plant, the heat produces steam to spin the turbines, which generate electricity.

The heart of a nuclear power plant is its reactor core. There, pellets of uranium fuel are stacked in fuel rods. Control rods composed of materials that absorb neutrons and thus prevent the chain reactions from going out of control are interspersed with the fuel rods. When the control rods are pulled up and out from between the fuel rods, the reaction can take place.

Water flows in and around the entire reactor core. This serves a number of functions. First, it slows the neutrons to the proper speed for nuclear fission to take place. Second, it cools the core and prevents the fuel from overheating. Third, it carries energy in the form of steam to the turbines where the electricity is generated.

The reactor core is enclosed in a stainless steel pressure vessel, which in turn is surrounded by a concrete containment wall, usually four or more feet thick. The containment wall is what you see when you look at a nuclear reactor from the outside.





will produce electricity at a cost of 3.75 cents a kilowatt hour in 1990, compared with 4.8 cents for coal and 6.05 cents for oil.

Opponents dispute these figures. They claim that uranium fuel costs will rise at a faster rate than industry predicts, and, furthermore, that there are a number of hidden costs not included in the industry figures. These include the cost of disposing of nuclear waste and the cost of decommissioning nuclear power plants when they wear out. They also note that the government subsidizes the nuclear fuel enrichment process and pays for most research and development of new technologies.

Nuclear Proliferation

Although the United States has the largest number of nuclear reactors and generates the most electricity with nuclear energy, it is by no means the only country with a substantial commitment to nuclear energy. Great Britain and France both rely on nuclear power to supply a higher fraction of their total energy needs than does the United States.

In recent years a number of developing countries have also begun to use nuclear power. This has caused a great deal of concern about the proliferation of nuclear weapons, because the technology for a nuclear reactor is closely related to the technology for nuclear weapons material. For this reason, Congress has insisted it have the power to block the sale of fuel and equipment for nuclear power plants to countries that have not signed the Nuclear Non-Proliferation Treaty.

New Technologies

Several new technologies for nuclear power generation are being developed. Probably the most promising of these are breeder reactors and nuclear fusion. Breeder reactors actually create more fuel than they consume. However, they are more dangerous than conventional reactors, and they create large amounts of plutonium. An experimental breeder reactor is now being built in Tennessee.

Another promising new area is nuclear fusion, an energy process similar to that which releases the sun's energy. In nuclear fusion, hydrogen molecules fuse to form helium molecules — and energy. Fusion seems to hold the promise of virtually limitless energy without environmental costs. However, fusion produces so much energy that the problem is to avoid melting everything surrounding the reaction.

The Future of Nuclear Energy

As supplies of oil and gas become more scarce and more expensive, the need for other sources of energy such as nuclear power increases. Nuclear power can obviously fill a real need. However, the costs of nuclear power cannot be ignored. The costs and benefits of nuclear power need to be weighed against the costs and benefits of alternatives. Government will be involved in making the decisions about the future of nuclear energy in the United States. But for policymakers the key question is: What role should the government play in nuclear energy?

What Happened at Three Mile Island?

At four o'clock on the morning of March 28, 1979, a minor pump failed in Unit Two of the Three Mile Island Nuclear Power Plant on the Susquehanna River near Harrisburg, Pennsylvania. From that small beginning, a series of mechanical malfunctions and operator errors combined to produce an accident of major proportions. The net effect of the failures was that water needed to cool the reactor core escaped from the core. The fuel rods in the reactor core, left bare in the absence of cooling water, began to overheat. If left bare long enough, the rods might have become hot enough to melt the steel reactor vessel and, in the worst case, crack the concrete containment wall of the reactor. Fortunately, that did not happen. Instead, the emergency cooling system was triggered, flooding the reactor core.

However, another problem developed. Water in the reactor reached such high temperatures that it began to break up into hydrogen and oxygen molecules. A hydrogen bubble formed at the top of the reactor, a development that caused great concern. If the bubble had grown too large, it might have prevented cooling water from reaching the fuel rods. Worse, the presence of hydrogen and oxygen might have resulted in an explosion. A small explosion did occur, but fortunately the bubble began to shrink on March 31, and the worst fears went unrealized.

Clean-up of the Three Mile Island accident has not been easy, and is a long way from complete. At first, industry spokesmen confidently predicted the plant could be cleaned up and reopened. Now it looks as though Three Mile Island will never operate again. Eventually the plant will be decommissioned, but the immediate challenge is to remove the 690,000 gallons of radioactive water left in the reactor.

The long-term effect of the Three Mile Island accident on the nuclear industry is not yet clear. Immediately after the accident, the Nuclear Regulatory Agency (NRA) imposed a temporary moratorium on the construction of nuclear power plants. This has since been lifted, but utilities have been hesitant to commit themselves to future construction. This reluctance is only partly due to the legacy of Three Mile Island. Other factors such as nuclear waste disposal and rising construction costs have also been working against nuclear power. But in the words of one nuclear power official, "Another Three Mile Island could mean the death of nuclear power in this country."

Points of View

The Case For Nuclear Power

Atomic Industrial Forum

The Atomic Industrial Forum is a non-profit organization supported by donations from utility companies.

Energy's importance to economic well-being and employment is well established. Generating the increases in productivity and income that we call prosperity requires that output grow faster than employment. And for this to happen, energy use also must grow faster than employment. In fact, the consumption of energy per productive job continues to rise.

The solution can be found in the fastest growing segment of our energy system — electricity — and its fastest growing source — nuclear power. Historically, we have experienced a 7 percent average annual increase in electrical output, compared to a 3.5 percent increase in gross energy consumption. Even with conservation, near-term electrical growth is presently projected at 4.3 to 4.7 percent per year.

Currently about 9 percent of the oil and more than 16 percent of the gas we consume are burned to generate nearly one-third of our electricity. The opportunity for substantial savings is clear: eliminate the use of oil and gas for electrical generation, replace them with available alternatives such as coal and uranium and use electricity itself as a substitute for scarce liquid fossil fuels wherever possible.

Commercial nuclear power plants in the United States have accumulated more than 460 reactor-years of operation. During the two decades this nation has gained the economic and environmental benefits of nuclear energy:

- No injury to the public has occurred.
- No plant employee has been seriously injured by exposure to radiation. This record of safety is unparalleled by any other industrial experience.

As traditionally envisioned, spent fuel would be transported after several months' cooling to reprocessing plants for recovery of residual uranium and newly generated plutonium.

On April 7, 1977, however, commercial reprocessing in the United States was deferred indefinitely as part of a presidential policy to reduce the risk of nuclear weapons proliferation.

As a result, reactor water basins must now be modified to store not relatively small amounts of spent fuel for several months but much larger quantities for several years.

Options *are* available to develop means for the permanent disposal of nuclear waste.

Indeed, one problem is that there are a number of approaches, each of which appears probable of success. Ironically this diversity of available approaches apparently has diverted focus away from a specific solution.

Importantly, the president and Congress must commit the federal government to a well-defined program leading to an early first repository, reflecting its conviction that nuclear waste will be disposed of with no significant risk to the public.

To ensure progress, early and intense development of repository sites and technology is essential to a sufficient-

The Case Against Nuclear Power

Union of Concerned Scientists

The Union of Concerned Scientists is a non-profit organization composed of scientists and other citizens opposed to rapid development of nuclear power.

The safety problems affecting nuclear plants are very serious. Nuclear plants can have truly catastrophic accidents. The danger is not a nuclear explosion, but the sudden release of lethal, radioactive material into the environment.

It is true that so far there have been no calamitous accidents in the country's limited commercial nuclear power program. But only 72 of the hundreds of reactors planned have been built, and already there have been a number of very sobering near-misses, many pointing to inadequate designs and poor supervision. The 1979 accident at Three Mile Island destroyed much of the core and came within an hour of a meltdown, according to accident reports. In 1975, many of the safety systems, including the entire ECCS, (Emergency Core Cooling System), were knocked out for more than seven hours at one of the country's largest operating plants in Browns Ferry, Alabama, by a fire started by a workman's candle. One TVA official told investigators that a catastrophe was avoided by "sheer luck." The nuclear industry and government claims that the risk from the nuclear program is negligible are called into serious question by events such as these.

And it is not just accidents that are cause for concern. Reactors can be sabotaged with catastrophic consequences. Repeated studies by government and other reviewers have concluded that safeguards against sabotage are presently inadequate.

Another danger of the nuclear power program lies in the highly toxic radioactive waste generated by nuclear reactors. Scientists have described this as a grim legacy to future generations. This waste, although relatively small in volume, will continue to be deadly for tens of thousands of years. Unlike chemical pollutants, there is no way to render this waste harmless; it must be stored and guarded until the natural radioactive decay has run its course. If prehistoric cavemen had generated nuclear wastes, our society would still be confronted with containing their lethal potency.

Accidental release of radioactive material or waste is not the only kind of danger surrounding nuclear power. Another danger involves the production of atomic bomb materials. A typical plant produces 500 pounds of plutonium a year, and it takes only 20 pounds to make a bomb. If, as the nuclear industry wishes, this material is separated out and becomes available for theft, the possibility of terrorist acquisition will be vastly increased.

An additional and frightening dimension of nuclear power involves export sales of reactors. Nations not having nuclear weapons can buy reactors and use their nuclear technology as a stepping stone to nuclear explosives. India demonstrated this threat when it surprised the world by detonating a nuclear explosive built with material from a reactor furnished by Canada. Control over the reactors we

The Case For Nuclear Power

continued

ly focused and reliably managed program for solving the issue of high level nuclear waste.

Delaying crucial decisions will guarantee further impediments to a solution rather than achieve an effective resolution.

Currently operating nuclear plants produce electricity on the average for about 45 percent less than the weighted average cost of all coal- and oil-fired generation. No other energy option currently available offers the prospect of comparable near-term savings.

Most importantly, only reliance on nuclear power today can help assure the adequacy of energy supply tomorrow.

The Case Against Nuclear Power

continued

and other major countries sell abroad is inadequate, and so the proliferation of nuclear weapons can continue much too easily.

The dream of cheap, abundant power from nuclear reactors has continued to fade as the economic realities have emerged. Nuclear plants are extremely expensive to build, and costs are increasing at the rate of more than 20 percent annually. Further, these plants are very complex to run, and they have many inefficiencies. Commercial U.S. nuclear plants operate at about 59 percent of their capacity, far below industry and government projections of 70 to 80 percent. Nuclear-generated electricity now costs more than that generated by coal in some parts of the country, and almost as much as oil.

UCS and many other concerned citizens do not deny the energy potential nuclear power could offer the United States. Our position simply recognizes that satisfactory safety precautions must to be taken before large-scale nuclear power production can be allowed. The nuclear industry has failed so far to do this. A moratorium on the construction of new plants would allow an orderly assessment of the problems, and would afford the time to carry out research and development to decrease the risks. This would help avoid costly and possibly fatal mistakes. The history of indifference, carelessness, poor engineering, near accidents and suppression of information to the public about nuclear safety problems demonstrates the need for considerable tightening of controls.

No Easy Answers: Energy and the Environment

Millions of years of heat and pressure have transformed decayed plant matter into fossil fuels: coal, oil and natural gas. Today that decayed plant matter is of enormous importance to the modern world. In fact, the history of industrialization is largely the history of learning to harness the energy of fossil fuels. First coal, then oil and natural gas were tapped to fuel the machines of industry, to transport people from place to place and to heat and light homes. Fossil fuels are the basis of the lifestyle we have come to enjoy.

For many years, consumption of fossil fuels in the United States increased year by year with little concern for the environmental consequences. Eventually, however, the quantities of gasoline burned by automobiles and of coal burned by electric utilities threatened the ability of the environment to absorb all pollutants that were released.

In the 1960s environmental issues became a strong concern of many Americans. Most people agreed that our air and water were intolerably polluted and needed to be cleaned up. Congress passed laws and approved regulations to improve air and water quality. Anti-pollution devices were required on automobiles, even though they decreased fuel-efficiency and increased cost. Laws were passed promoting the use of clean-burning oil and natural gas in factories and power plants instead of soot-producing coal. Environmental regulations requiring coal companies to repair land ripped apart by coal strip-mining drove up the price of coal. As a result, America used less of its vast coal resources and more oil, much of it imported.

Most of these laws and regulations were created when supplies of oil and gas were abundant and inexpensive. Today, however, shortages of domestic oil and the high price of imported oil have brought our concern for the environment into conflict with our need for energy. Many of the fuels we would like to use as alternatives to oil and gas—coal, synthetic oil and gas made from coal, shale oil, tar sands, nuclear energy—have great environmental costs associated with them. Acid rain, the destruction of scenic wilderness areas, the loss of valuable water resources and the threat of nuclear contamination from disposed nuclear waste are problems we must face as we rely less on oil and natural gas. The question we must ask is: How can we increase our energy supply without destroying our environment?

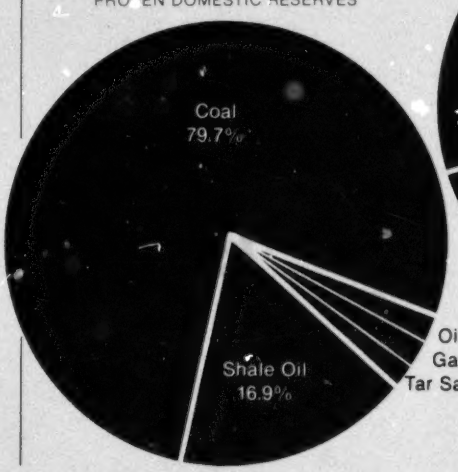
Oil, Natural Gas and the Environment

Oil and natural gas are the two largest sources of domestic energy. In 1980 the United States produced 3.139 billion barrels of oil (18 quadrillion Btus, "quads" for short. See glossary for definition.) a year and 19.3 billion cubic feet of natural gas (19.72 quads) a year. Unfortunately those production rates are higher than the rate at which new reserves are being found, and the United States is slowly draining its reserves of both oil and natural gas. How long these reserves will last is an open question, but experts agree they will not last forever.

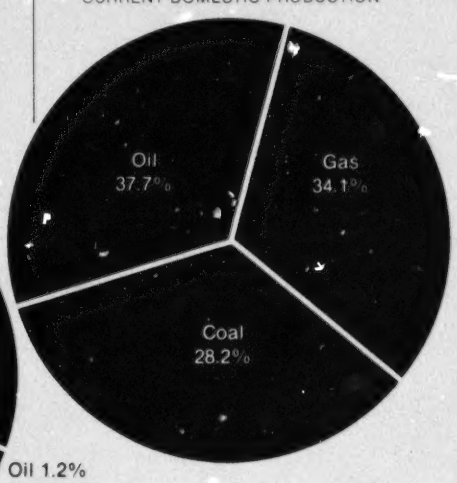
The domestic oil and gas picture appears less bleak today than it did a few years ago. Then it seemed the United States was in imminent danger of running out of energy. Domestic production lagged, while consumption continued to grow. Imports represented nearly 50 percent of our oil supply, and the share was growing. The trends looked ominous. However, since then the picture has changed for the better. Domestic production has gone up and consumption down. Imports have been reduced dramatically. Many Americans believe the energy crisis is over.

One important factor in both the problem and the turnabout was government price controls. In 1971 the federal government placed controls on oil and gas prices to protect consumers from rapidly rising energy prices. Unfortunately, price controls had the effect of discouraging domestic oil production, especially in fields where oil was difficult to extract. Energy companies found it more profitable to import oil from Saudi Arabia and other countries. The amount of oil imported into the United States increased dramatically. To spur domestic production and lessen dependence on imported energy, oil prices were decontrolled in 1980. Decontrol of domestic oil prices has stimulated a large increase in the number of exploratory wells being drilled. In 1980, 59,000 wells were drilled in the United States, a record number. Despite the dramatic increase in drilling, however, there has not been a corresponding increase in the amount of oil and gas discovered.

PROVEN DOMESTIC RESERVES



CURRENT DOMESTIC PRODUCTION



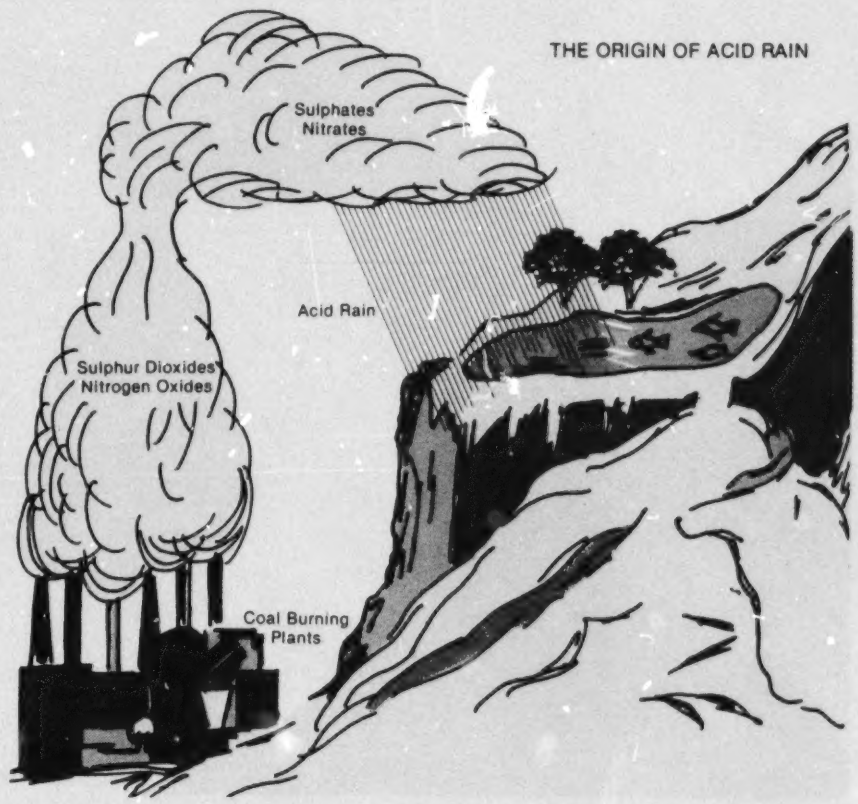
THE FUTURE OF FOSSIL FUELS

Because most of the oil and gas in the United States has already been found, an increasing percentage of U.S. production will have to come from the utilization of "enhanced recovery" techniques, which can recover some of the oil and gas now left in the ground. The average oil well extracts only 32 percent of the oil in the ground (and often some natural gas that might also be in the well). In addition, large amounts of natural gas are trapped in coal seams and rock formations not easily tapped by conventional methods. Enhanced recovery techniques will be more common as the price of foreign oil rises.

The major environmental problems with oil and gas come from burning gasoline in cars and trucks. Over the years, as Americans drove more and more vehicles, air pollution from auto and truck exhaust became a serious hazard in many urban areas. In the 1970s Congress enacted legislation that set standards for auto emissions. The requirements have been successful in improving air quality and reducing health problems, but they have also cost auto manufacturers substantial profits and have made cars less fuel efficient than they would otherwise have been.

Drilling for oil or gas, at least on land, is considered environmentally safe compared to most methods of extracting minerals. Drilling for oil at sea, however, could have a much greater impact on the environment should something go wrong. In January 1969 an oil spill from a well off the coast of Santa Barbara formed an 800 square mile oil slick, coating 30 miles of beach, severely damaging boats and killing hundreds of waterfowl. Although off-shore drilling is much safer now, memories of the Santa Barbara spill provoke angry opposition to off-shore drilling from environmentalists and residents of coastal communities.

Because the long-term outlook for oil and gas is so unpromising, most energy observers expect a shift away from those fuels toward coal and synthetic oil and gas made from coal, shale oil and tar sands. Estimated recoverable reserves of oil and gas in the United States are 29.5 billion barrels (171.1 quads) and 201 trillion cubic feet (204 quads) respectively. Estimated reserves of other fossil fuels include 246 billion short tons (5,560 quads) of coal, 418 billion barrels (2,424.4 quads) of shale oil and 27 billion barrels (156.6 quads) of oil from tar sands. Obviously, if fossil fuels have a future in America, it lies with these three sources. But despite their promise as answers to America's energy needs, these sources also share a major drawback—their use is environmentally damaging.



Coal

Ever since the Arab Oil Embargo of 1973, when America first realized it had an energy problem, coal has been heralded as the energy source of the future. With 27 percent of the world's coal reserves, the United States is the "Persian Gulf" of coal. Yet in 1981, eight years after the Arab embargo, the coal industry was operating at 100,000 tons a day below its maximum capacity, and 20,000 coal miners were out of work. In addition, despite the substantial price advantage of coal over oil and natural gas, demand for coal has not increased at any extraordinary rate.

Part of the problem involves the inherent limitations of coal. Coal is difficult to mine, expensive to transport, and awkward to use. The last point is particularly significant: You cannot put coal in your gas tank. At present, coal is used primarily to produce electricity and to produce process heat for industry.

Mining coal also creates problems. Unfortunately, a high percentage of America's coal reserves lies near the surface in deposits that can only be mined by stripping away the top layer of earth. Once it has been stripped, it is very difficult to return the land to its original condition. Underground mining, although environmentally preferable to strip mining, is dangerous to people who work in mines. Fatal accidents and black lung disease among miners are the most serious hazards. Environmental regulations concerning strip mining and safety regulations governing underground mining add to the cost of coal.

The environmental costs of burning coal are also significant. Direct burning produces three kinds of pollutants: sulfur dioxide, nitrogen oxide and particulates (soot). All three are health hazards. Sulfur dioxide and nitrogen oxide are also apparently

responsible for acid rain. In the upper atmosphere these chemicals change to sulfate and nitrate. Then they combine with moisture to produce acid rain. Environmentalists and coal spokesmen agree that acid rain has detrimental effects, but they disagree about how serious a problem acid rain is, and about whether coal plants are the culprit. According to the Environmental Protection Agency (EPA), acid rain has killed all living organisms in many northeast lakes. Many Canadian lakes have suffered the same fate, as pollutants from U.S. factories have been carried north by prevailing winds. Apparently, rainfall raises the acidity of the lakes beyond the level at which organisms can survive.

A heated debate centers on the environmental regulations that limit the amount of pollution coal burners may produce. Industry spokesmen point out that much research must be done before the relationship between coal plants and acid rain can be firmly determined. They note that it costs money to clean the emissions from a coal burning plant. A conventional coal plant uses "scrubbers" in its smokestack to filter out most of the harmful emissions. According to the Edison Electric Institute, a utility research organization, it can cost $50 million to install scrubbers at a large power plant. Most producers and consumers of coal feel the EPA's requirements are too strict. Environmentalists argue that the evidence is sufficient to justify further controls on the emissions from coal plants.

Whether scrubbed or not, large-scale burning of coal would also increase the levels of carbon dioxide in the atmosphere. Coal, because of its composition, produces a large quantity of carbon dioxide when burned. Increased levels of carbon dioxide in the atmosphere may contribute to higher global temperatures and changes in the world's climate.

The Synfuels

Oil and Gas from Coal

The problems with using coal in its solid form—the cost of transporting it, the difficulty of using it, and the environmental drawbacks—have sparked interest in producing synthetic oil and gas from coal. Easier to transport than solid coal and usable in more situations (you can put it in your gas tank), synfuel produced from coal could be a major energy source in the future. In 1980 Congress passed a bill creating the Synthetic Fuels Corporation, which is authorized to spend $20 billion to promote the development of synthetic fuels. The corporation can help young synfuel companies by offering to purchase future oil the companies develop, by establishing price supports, by providing or guaranteeing loans for capital expenses, or by joining a company in a partnership.

The technology for producing gas and oil from coal is not new. The Germans used synthetic oil during WWII. The Chinese and the South Africans use it today. And coal gas was a common fuel for cooking and street lighting in the 19th and early 20th centuries. However, for most of the 20th century, the cost of converting coal to liquid and gas was much higher than the cost of oil and natural gas. Now the economic picture has changed again. Domestic price increases for oil and natural gas may have made synfuels competitive again.

Large-scale synfuel production from coal would have some significant environmental costs, however. Increased coal mining would exacerbate such problems as black lung disease and accidents from underground mining, and land disruption from strip mining. In addition, the synfuels process requires enormous amounts of water. This could be of major significance in the West, where water is already in short supply. Converting coal to gas *in situ* (in the ground) would have environmental advantages, but the technique is as yet largely unproven.

Shale Oil

Another potential source for synthetic fuel production is oil shale. Oil shale is a rock that contains kerogen, a substance that can be heated and decomposed into shale oil. Although little oil is obtained from shale today, shale oil could be a major source of energy in the future. The United States has approximately 418 billion barrels that are considered recoverable. That amount dwarfs the petroleum reserves in the United States (29.5 billion barrels). Oil can be obtained from shale either by mining the shale and bringing it to the surface to be heated(surface retorting) or by heating the rock underground *(in situ* retorting) and then pumping out the resulting oil.

There are drawbacks to both processes. Surface retorting requires mining enormous amounts of shale. To produce 55,000 barrels of oil a day, a plant requires more than 50,000 tons of high oil content shale. The environmental consequences of mining so much shale are substantial as well, especially if the shale is strip mined. Large expanses of land are disrupted. Blasting, mining, transporting and retorting the shale pollute the air and water. And the spent shale must be disposed of. This last problem is particularly troublesome, because spent shale has a volume 1.2 times greater than the original rock. The larger volume makes it impossible simply to put spent shale back where it came from.

Tar Sands

Oil can also be obtained from tar sands. Tar sands are loose formations of rock and sand containing bitumin, a very thick form of oil. Although the United States has relatively little tar sand compared with Canada and Venezuela, 27 billion barrels of oil could be obtained from this source. Most of the reserves in the United States are located in Utah.

The technology for obtaining oil from tar sands is very similar to that for obtaining oil from oil shale. Tar sands can either be brought to the surface and heated, or they can be heated in place to thin the oil sufficiently to pump it out. The environmental consequences of obtaining synthetic oil from tar sands include air pollution, the use of large quantities of water, the contamination of water, and the disruption of land—the same problems associated with the production of synthetic oil from shale.

The Synthetic Fuels Corporation

Despite the need for synthetic fuels development, economic obstacles remain. Because the initial investment for a synfuel plant is enormous—more than $1 billion—industry has been hesitant to commit itself to synthetic fuels. Congress created the Synthetic Fuels Corporation in 1980 to encourage investment in synthetic fuels, but the Reagan administration has scaled down the corporation from its congressionally mandated goals. Instead of handing out seed money for new plants, the corporation will now select a few plants to serve as models for private companies that want to build privately financed plants.

Nuclear and Renewable Energy

The alternatives to fossil fuels are nuclear and renewable energy. Both

have limitations that prevent them from assuming a large share of the energy burden, at least in the foreseeable future. Nuclear energy, once heralded as a "clean" energy source, is now being reconsidered because of the threat to the environment of nuclear waste. As discussed in the previous chapter, the contaminated waste we bury today may be an environmental time bomb that will create severe problems 100 years from now.

Renewable sources of energy, including solar, biomass, wind and geothermal energy, are clearly much better for the environment, but they may not be usable on a large scale for some time. The potential for renewable energy will be discussed in the next chapter.

Energy Needs and the Environment

It is apparent that new sources must be developed if fossil fuels are to maintain their prominence in the American energy picture. The amount of energy stored in America's coal and oil shale reserves is enormous. New techniques may soon make it economical to use these sources. But it remains to be seen whether the environmental costs of these forms of energy can be balanced with their benefits. For policymakers the key question is: How much government regulation is necessary to balance energy needs and the environment?

Points of View

The Environmental Costs of Synthetic Fuels

Robert L. Roach

Mr. Roach is the director of the Synthetic Fuels Assessment Project at the Environmental Policy Institute in Washington, D.C.

The production of large amounts of synthetic fuels will require tremendous amounts of coal and oil shale. Coal liquefaction optimally yields 27-35 gallons of fuel per ton of rock. Thus each plant will use 20,000-100,000 tons of coal and shale per day. The massive strip and underground mining required to meet such needs threaten vast tracts of land with destruction, especially in arid western regions. There will also be enormous waste disposal problems. Each coal plant will generate 600,000 to 4 million tons of waste per year. Each shale plant will produce 23 million tons of waste per year. Further compounding the problem, the waste will be laden with toxic and carcinogenic substances.

Most of the plants will be located in the West. The tremendous amount of water utilized in these technologies will place an added burden on already limited water supplies. Each coal liquefaction and oil shale plant will use 5 to 10 million gallons of water per day. Gasification plants will require several times as much water.

In addition to the problem of consumption, water supplies are threatened with contamination. The mining of coal and shale and the underground processing of oil shale could disturb aquifers. Leaching from waste could deposit toxic and carcinogenic substances in the groundwater.

Each plant would also emit tons of sulfur and nitrogen oxides, carbon monoxide, hydrocarbons and particulates each day. Additionally, a large synfuels program would hasten the build-up of carbon dioxide (CO_2) in the atmosphere. The production and use of synthetic fuels would release far more CO_2 than would comparable amounts of other fossil fuels (1.4 times as much as the direct combustion of coal, 1.7 times as much as burning oil, 2.3 times as much as burning natural gas).

Finally, workers in coal and shale oil plants will be exposed to toxic and carcinogenic substances. The Department of Energy has pointed out that even the transportation and end use of coal-based liquids may pose exposure problems.

The Need for Synthetic Fuels

Senator J. Bennett Johnston

Senator Johnston, a Democrat from Louisiana, serves on the Senate Energy Committee. These remarks were made during the debate on the Synthetic Fuels Corporation, November 5, 1979.

Coal gasification and the extraction of liquid fuel from both coal and oil shale are two of the most promising energy alternatives. With known recoverable deposits of 215 billion tons, coal accounts for almost 85 percent of our fossil fuel reserves, but provides only 18 percent of our energy needs. Coal gasification and liquefaction require no technological breakthroughs. What is needed are demonstrations of commercial feasibility. The immediate need is to develop a number of commercial-size synthetic fuel plants that would be sufficient to demonstrate the technology, environmental effects and economic practicality of various synfuel options. There should be no artificial ceiling placed by Congress on the size plant that may be constructed or on the technology to be used. Rapid expansion to full-scale production goals demands a comprehensive initial effort.

There can be no question that synthetic fuels offer a long-term solution to our energy problems. Conservation is undoubtedly the short-term answer to reducing our immediate need for imported oil. But there is no practical substitute for liquid fuels for our present transportation system. Our national defense network is built under the implicit assumption that our modern weapons can be fueled with petroleum-like products. Synthetic fuels from coal and oil shale have the potential for providing significant amounts of such future energy supplies, but the effort must begin now. A fragmented program, rather than a definitive, long-range federal policy, will irreparably delay the development of commercial synthetic fuel capability, and will only further protract our intolerable reliance on foreign oil.

Tapping the Future: The Case for Renewable Energy

A hundred years ago, America depended on renewable resources for most of its energy. Wood for heating homes and fueling industry, and falling water for mechanical energy were the primary forms of energy. Then, with the onset of cheaper energy in the form of fossil fuels, these sources were largely abandoned. Now the situation has changed again. Rising prices of fossil energy, along with increasing concern about its environmental impact, have heightened interest in returning to these and other forms of renewable energy.

Eventually America will have to depend on renewable sources of energy. There is only so much energy available in the form of fossil fuels and uranium. In contrast, the energy available in renewable forms is vast and virtually inexhaustible. Most of this energy is solar energy captured in one of a variety of ways. Direct heat from the sun, plant life and ocean currents are some of the forms of solar energy. In addition, ocean tides, caused by the gravitational force of the moon, and geothermal energy, caused by slow radioactive decay deep within the earth, are renewable forms of energy we can use.

Together these forms of energy have enormous potential. Unfortunately, they are not the kind of concentrated energy our present technology is equipped to capture. Before renewable resources can supply more than a modest fraction of U.S. energy demand, new technologies must be developed. There is no debate as to the benefits of moving toward utilizing these sources. The only questions are how to do it and how soon renewable resources can be a real alternative to fossil fuels.

Types of Renewable Resources

Conservation—The energy saved by conservation, "conservation energy," is often included under the heading of renewable resources. The United States uses more energy per capita than any other country in the world. According to the Department of Energy, conservation is "the quickest and least expensive means of reducing U.S. dependence on foreign supplies of oil."

An influential study conducted by a task force at the Harvard Business School concluded that the United States could save up to 40 percent of the energy it now uses, and recommended that the federal government focus its efforts on encouraging conservation (and solar energy) rather than on encouraging the development of fossil fuel or nuclear energy. This study has been criticized by some who think it gives up too easily on traditional forms of energy and is unrealistically optimistic about the potential for conservation and solar energy. It does seem clear, however, that a large amount of energy could be saved if we were to use energy more efficiently.

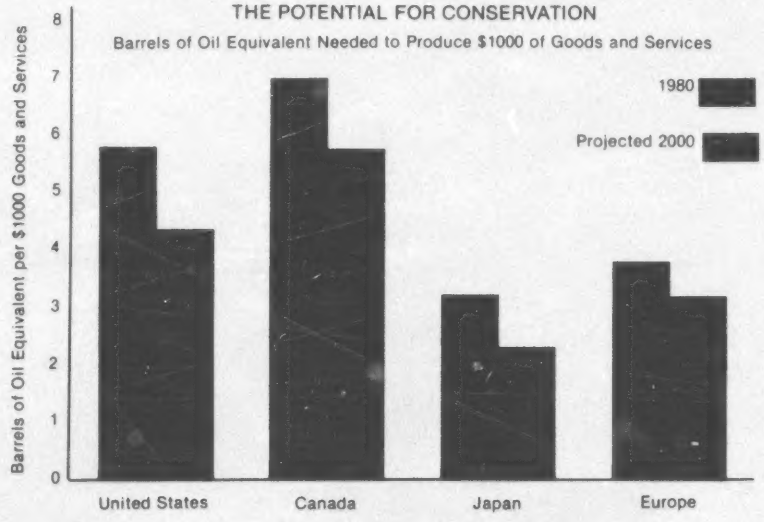
Buildings could be constructed that would use 50 percent less energy than today's buildings. Glass skyscrapers, for example, are tremendously inefficient. The World Trade Center in New York uses as much energy as the entire city of Schenectady, New York, which has a population of 77,000. Unfortunately, according to the Department of Energy, the average building stands for 100 years, which means it will be a long time before energy-efficient buildings are commonplace. Automobiles, on the other hand, are replaced every ten years on the average. Improvements in their efficiency can take effect much more quickly. Already the fuel efficiency of automobiles has been greatly improved. Much of this improvement is attributable to government regulations and higher oil prices, which have increased consumer demand for cars that use less gasoline.

Many industries are now considering ways to conserve some of the energy they use. One promising method is cogeneration, whereby waste heat from electricity generation is used as process heat in industrial applications.

Government programs to save energy include requirements that new cars meet certain fuel efficiency standards, tax credits for Americans willing to install solar energy units or improve insulation in their homes and the 55 mph speed limit. Higher prices for gas and oil resulting from decontrol encourage further conservation.

President Reagan, however, has cut from the budget several programs intended to encourage conservation. Among them are the Solar and Conservation Bank, which would have provided low-interest loans for energy-saving home improvements, and a program that would have required new buildings to meet energy efficiency standards.

Solar—It is difficult to comprehend the amount of solar energy that



reaches the earth. A square of land 75 miles by 75 miles in a desert region receives enough energy from the sun to supply all of the United States' energy needs. Because the methods for harnessing solar energy are less than totally efficient, however, a considerably larger area would actually be needed to meet that need. Solar energy is an extremely diffuse energy source. For this reason, emphasis on solar energy is placed either on concentrating it into usable forms or using it in applications in which diffuse energy will apply.

The most promising immediate application of solar energy is home space and hot water heating. Solar energy for these uses can be captured in two ways: through passive systems and through active systems. Passive systems are built into the design of a building. They usually consist of expanses of glass that capture sunlight, and of surfaces painted black that absorb the incoming rays of the sun. In addition, water or slabs of concrete store energy for use when the sun is not shining. Active systems involve a higher initial investment because they have moving parts and involve more elaborate technology. These systems usually concentrate solar energy to produce higher temperatures, and use water or another transfer fluid to distribute the heat. Active systems may also convert solar energy to other forms of energy such as electricity.

A technique for producing electricity directly from solar energy, called photovoltaic conversion, also has a number of immediate applications. When sunlight strikes materials called semi-conductors, small amounts of electricity are produced. Photovoltaic cells made from semi-conductors are used to power satellites in space and in other situations too remote for other sources. The most commonly used material for semi-conductors is silicon, which is found in sand. Although the basic material is inexpensive, the cells themselves are still too costly for most uses. Should there be a breakthrough in the price of photovoltaic cells, electricity from the sun could be an important energy source for home and industrial use.

Solar energy for industrial use has been limited because most of the energy used by industry is used to produce process steam and process heat. This requires high temperatures and concentrated energy. Some experimentation is being done on large-scale solar concentrators, which usually consist of an array of mirrors that follow the sun and concentrate sunlight on a very small area. Other more elaborate technologies are also in the research stage.

Besides supporting research and development of solar energy, the federal government provides incentives to encourage its use, including tax credits for installing solar collectors in private homes. In 1980 at the request of the Carter administration, Congress created the Solar and Conservation Bank to encourage the implementation of solar technology in new and old homes. The Reagan administration, however, omitted all funding for the bank from the 1982 budget, keeping with its efforts to cut the budget and to shift responsibility for solar energy development to the private sector. In the end Congress appropriated $25 million for the bank — down from the $125 million budget requested by President Carter.

The outlook for solar energy in the near future is mixed. Much depends on the rate at which improvements in design reduce the cost of solar energy as compared with other energy sources. At the moment, only passive heating for homes is competitive in the market.

Biomass—Biomass is a new term for a very old fuel, wood. Wood has always been burned for energy. Today, wood burning accounts for 2 percent of total U.S. energy consumption. America's forests cover 730 million acres. They contain energy equivalent to 51 billion barrels of oil. The forests themselves renew at a rate equivalent to 1.3 billion barrels of oil a year. The effectiveness of biomass as a means for energy collection has spawned interest in energy plantations, which would be planted with fast growing trees or other plants for the sole purpose of collecting energy.

Recently there has been a great deal of talk about gasohol, a combination of gasoline and alcohol made from crop residues. The experience of Brazil, where 20 percent of the energy for transportation comes from biomass conversion into liquid fuels, has encouraged exploration of the possibility of meeting U.S. energy demand with this source. Gasohol has received much federal support. The Energy Tax Act of 1978 exempts automotive fuels composed of at least 10 percent alcohol from federal excise taxes. Also passed during the Carter administration was the Energy Security Act of 1980, which included $600 million for Department of Agriculture biomass energy programs. The Reagan administration, however, has attempted to cut biomass energy programs from its proposed budget, because it believes alternative energy sources should be developed by the private sector.

Hydropower—Hydropower is really another form of stored solar energy. At one time, hydropower was utilized primarily for mechanical energy: for example, to turn the water wheels of grain mills. Today, however, it is used almost exclusively to produce hydroelectric power.

The basic technology is quite simple. A dam is built to create a large storage capacity at a certain level. Water is then allowed to flow from that level to a lower level, spinning the turbines that produce electricity. The greater the difference in elevation between the lake level and the turbines in the powerhouse, the more energy that can be generated.

Hydroelectric power accounts for 13 percent of the electricity generated in the United States. This capacity could be expanded, but public acceptance of large hydroelectric projects has diminished in recent years. Hydroelectric projects flood land that may include valuable farmland. They may also destroy areas of scenic beauty and disrupt the habitat of various forms of wildlife. For these reasons, many groups that normally support renewable resources oppose the expansion of hydroelectric capabilities.

Wind Energy—Wind has been used as a source of energy for centuries. Until relatively recently, wind was the main source of energy for ships. The Dutch and many others used windmills to catch the wind and turn it into mechanical energy. In the United States, wind energy was used extensively in rural areas for both mechanical energy and electricity. However, after World War II cheap electricity became available in rural areas. As a result, many windmills were abandoned. Today wind energy is on the upswing. The economic situation is making small windmills competitive again. Research is being done on new

designs for large windmills, and modern technology may put computer controlled sails on ships.

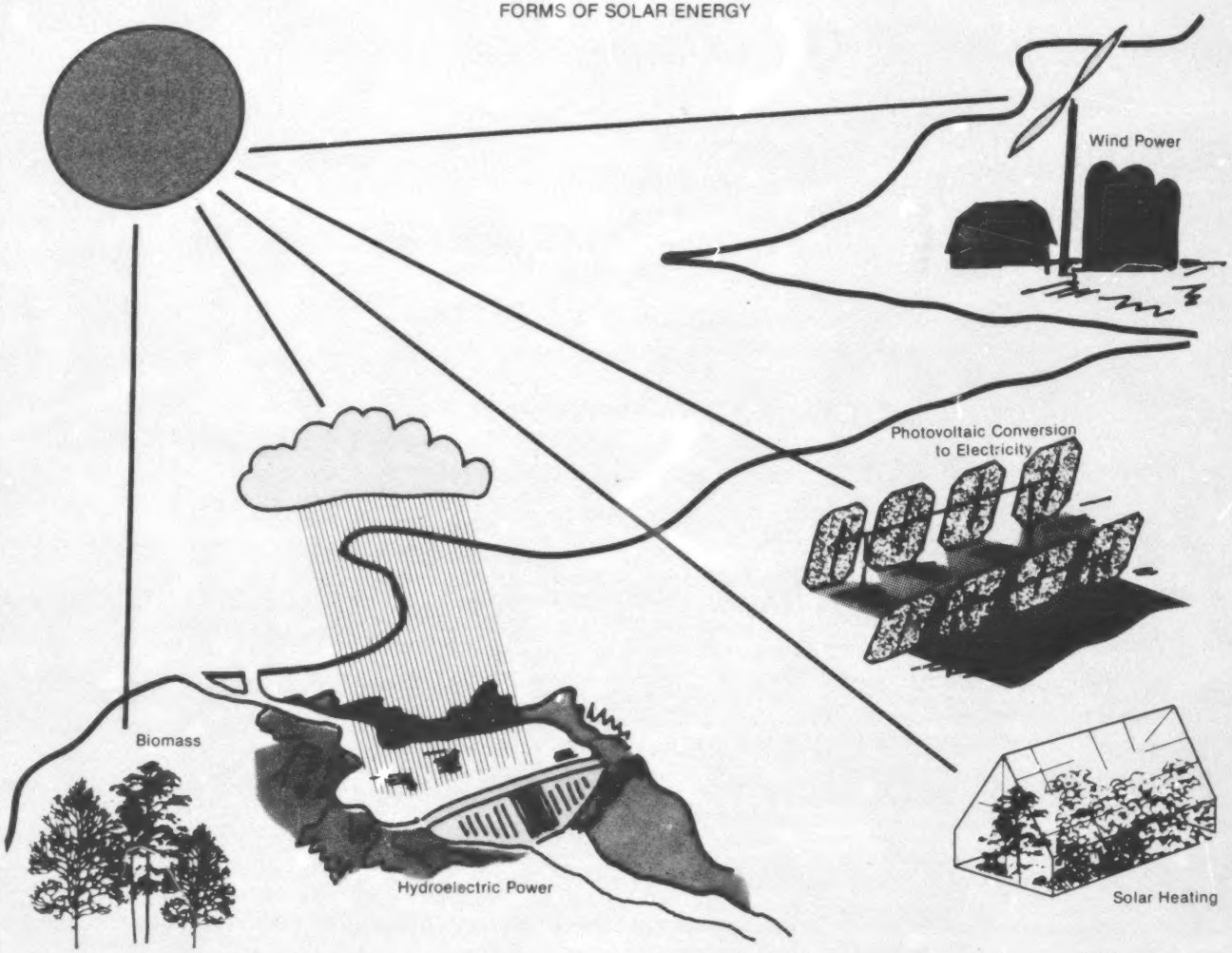
Geothermal Energy—Geothermal energy is heat generated deep in the earth. In many places it finds its way close enough to the surface to be harnessed for man's purposes. (Of course, in cases such as the eruption of Mt. St. Helens, this energy source may be too powerful to be harnessed.) The best bet for tapping this energy source in the near future is in places where the earth's internal heat comes in contact with water to produce steam. In California, the geyser's steam field is already producing electricity by spinning turbines in electricity generating plants. However, it will be some time before geothermal energy can be tapped on a large scale.

Ocean Energy—There is an enormous amount of energy stored in the oceans of the earth. Ocean currents, the difference in temperature between surface and deeper waters, and the power of tides may all someday be tapped. Suggestions for harnessing these forms of energy include large turbines placed in the path of ocean currents, dams in places with large tides, and floating energy stations that would utilize the difference in temperature between cold deep bottom waters and warmer surface waters. None of these techniques, however, is likely to produce enough energy for commercial use in the 20th century.

Conclusion

Without a doubt there is tremendous potential in the various forms of renewable energy. All but a few of these forms, however, are still far from commercial availability. It is not clear how soon we can reasonably expect these sources to supply a large share of U.S. energy needs. The key question for policymakers is: To what extent should government promote renewable resources?

FORMS OF SOLAR ENERGY



Points of View

Renewable Resources: A Real Alternative

Denis Hayes, former director of the Solar Energy Research Institute

This statement is excerpted from an article written by Denis Hayes for ***Perspectives 1981****, published by the Close Up Foundation.*

We at SERI are committed to attaining the goal of obtaining at least 20 percent of our energy from the sun by the end of the century. My own feeling is that 30 percent or even more is attainable if we invest sufficient dollars and dedication in both conservation and solar development. The stumbling blocks will be social and political — not technical or economic. We already derive about 6 percent of our energy from the sun in the form of hydropower and biomass fuels, including wood and agricultural wastes. This is twice the energy that nuclear power plants provide, but it is still a tiny amount compared with the solar energy that constantly falls on the United States. The sun delivers about 44,000 quads (quadrillion Btus; one quad is equivalent to 170 million barrels of oil) to the continental United States annually!

More than 50 percent of our energy is used for heating: space and water heating, industrial process heat, crop drying and other farm use. Solar energy is obviously well suited to filling these needs. Another 25 percent or so of our energy budget goes for transportation. We are now following Brazil's lead in adding alcohol from renewable resources to gasoline. Substituting alcohol for just 10 percent of our gasoline would save 10 billion gallons of gasoline a year. Research also promises the production of hydrogen, a very efficient and environmentally desirable fuel, using solar energy to drive the process. Methane gas can also be produced from biomass. Thus we can substitute widely available renewable fuels for dwindling petroleum resources found only in favored regions.

The Conservation Potential

Department of Energy

This statement is from the department's 1980 report to the president.

Conservation offers the quickest and least expensive means of reducing U.S. dependence on foreign supplies of oil. To be precise, one should use the term "conservation energy" because, in fact, conservation constitutes a vast domestic source of energy supply. Every barrel of oil saved is a barrel earned. In fact, it is often a barrel earned five times over because frequently one can conserve a barrel of oil five times more cheaply than one can be produced.

Conservation is already working. In the period 1950-1973, years of relatively cheap energy supply, energy consumption grew at an average rate of about 3.5 percent per year. During the 1960s, this annual rate actually topped 4 percent. In the post-oil embargo years, however, this figure fell below 1 percent, and in the period 1975-1979 energy demand increased only 65 percent as fast as the GNP.

But much remains to be done, and the Department of Energy actively stimulates and promotes conservation. DOE programs and policies seek a direct, immediate reduction in energy demand as well as increased efficiency in energy consumption by replacing current, inefficient products. Using such tools as financial incentives and assistance; research, development and demonstrations (RD&D); educational materials; and standards and regulations to implement its policies, the Department works to conserve energy in the building, industrial, transportation and utility sectors.

It is now well established that conservation is quite consistent with an expanding and dynamic economy. Conservation is an active, creative form of energy supply of benefit to every consumer. For the near term, many opportunities remain to employ currently available processes, techniques and technologies. In the mid- and long-terms, new technologies will steadily increase overall energy efficiencies as new buildings, appliances, autos and equipment continually replace those that waste energy.

Renewable Resources: A More Modest Assessment

Exxon Corporation

Exxon is the largest energy corporation in the world. This statement is excerpted from its ***World Energy Outlook,*** *published in December 1980.*

With continued technological development, renewable energy sources such as solar and eventually nuclear fusion will in all likelihood become major supply sources in the 21st century. Except for hydropower, however, the contribution of renewables to total energy supplies will be relatively small for the remainder of this century.

Some solar technologies are economic today in certain applications and locations. With the tax credit provided in the United States today, residential solar water heating is attractive to users in some areas, but generally only if competing with relatively high cost energy, such as electric water heating.

Photovoltaic electricity, the direct conversion of sunlight to electricity, cannot compete currently with central power grids, but is economical at remote installations, where the alternative is batteries or small diesel-driven generators. Although such installations may provide rapid growth for the photovoltaic industry, photovoltaics are not likely to be a significant part of the total energy supply until technological advances reduce costs to a tenth or less of current levels.

Even the modest contribution of solar energy projected in the *Outlook* requires that a substantial number of homes and commercial facilities use solar heat or hot water during the next two decades. Five million homes in the United States are projected to have solar domestic hot water systems and about 2½ million to have solar heating systems by the year 2000. About twice this number of installations are projected for outside the United States, principally in Europe, Canada and Japan.

Wind, wave and tidal power conversions to electricity are projected to contribute less than 100,000 barrels per day oil equivalent by the turn of the century.

The Energy Web: A Global Energy Picture

A common need connects all nations: energy. People everywhere use at least some energy to cook food and heat their homes. But beyond these basic needs, the developed economies of industrial nations and the emerging economies of Third World nations could not exist without abundant energy. A cutoff of oil, for example, would shut down factories, make it impossible for people to get to work, create tremendous food shortages and stop production of such oil-based products as synthetic fabrics, plastics and medicines. Eventually the economies of the entire world, even those of rich, oil-producing nations, would disintegrate.

Although the United States is one of the largest producers of oil, it, like most of the rest of the world—including developing countries in the Third World—depends heavily on oil exports from a few thinly populated Arab nations and some small, developing countries in Africa, Asia and South America. This dependence has given those oil exporting nations a strong degree of economic power.

Thirteen major oil exporting countries have organized themselves into a near monopoly called a *cartel*. A cartel is a group of producers who control the majority of the supply of a commodity, who agree to limit the amount of that commodity that reaches the market, and who agree to sell the commodity at a set price. The oil cartel, called the Organization of Petroleum Exporting Countries (OPEC), has forced the price of oil to rise from about $2 to $36 a barrel in less than 10 years. The higher prices have put a tremendous burden on the economies of Western and Third World nations, contributing to high inflation, lower productivity and world recessions.

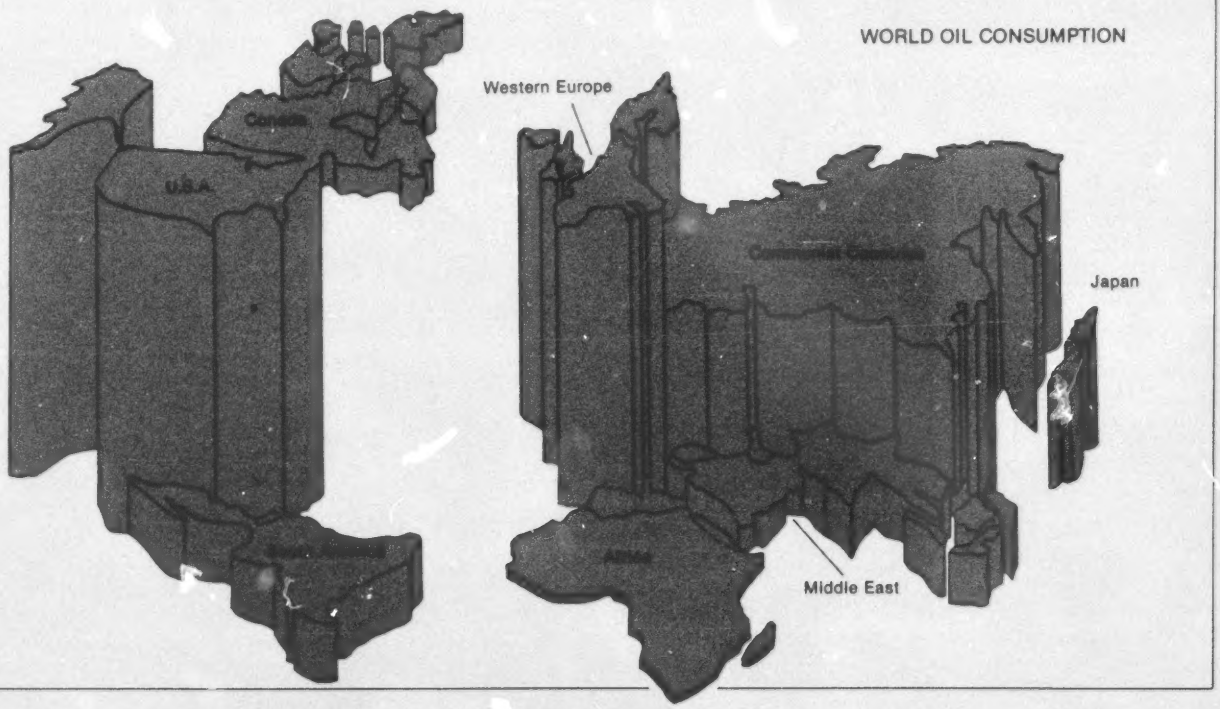
The ability to control the price and supply of oil has given OPEC nations tremendous political power as well. In 1973 OPEC first flexed its political muscle by forcing many Western nations to remain neutral during the war between Israel and Arab nations, and by forcing many Third World nations to break diplomatic relations with Israel.

In many ways, however, OPEC depends as heavily on the industrial nations as they depend on OPEC. Although the industrialized nations must import massive amounts of energy, energy exporters depend on the rest of the world for food, finished products and, most importantly, a market for their energy resources. If the world were to find alternatives to oil, then power would shift back to industrialized and food-producing nations.

The Energy Producers

Relatively few nations produce the world's traditional energy resources. The world's largest energy producers are, in order, the United States, the U.S.S.R., Saudi Arabia, China and Canada. As a group these five countries accounted for 59 percent of the world's energy production in 1980. However, of these countries only Saudi Arabia exported significant quantities of energy. The other four retained most of the coal, oil or natural gas they produced for domestic consumption.

Most of the world's energy trade consists of oil, although some countries also trade natural gas, coal and uranium for nuclear reactors. The result has been an unprecedented transfer of wealth (and power) from the oil importers (both the industrial nations and the Third World) to the oil



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exporting nations. OPEC nations have benefited the most from this transfer.

More than 56 percent of the world's oil is produced by the 13 members of OPEC: Ecuador, Venezuela, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, the United Arab Emirates, Algeria, Gabon, Libya, Nigeria and Indonesia. Saudi Arabia is by far the largest producer; in 1980 the Saudis produced 9.9 million barrels of crude oil a day. Only the Soviet Union produced more. However, the Saudis have a much greater oil reserve than do the Soviets, 168 billion barrels as compared to 63 billion barrels in Russia.

Non-OPEC countries with smaller levels of crude oil production, but with notable increases since 1973, include the United Kingdom, Mexico, China and Norway.

Other major energy sources are also produced by a small number of nations:

- Since 1973 production of natural gas has been dominated by the United States and the Soviet Union. These two countries produced 65 percent of the world's natural gas in 1980. Four other countries—the Netherlands, Canada, Mexico and the United Kingdom—provided an additional 15 percent.
- Three countries—the United States, China and the Soviet Union—accounted for 60 percent of the world's coal production in 1980.
- The United States, Canada, the Soviet Union, Brazil and Japan accounted for 53 percent of the world's hydroelectric power production in 1980.
- The United States, Japan, the U.S.S.R., France and the United Kingdom produced 73 percent of the world's nuclear power in 1980.

Energy Consumers

The largest consumers of energy are the industrialized nations of Europe, Japan and North America, which depend on oil to run their factories, farms and offices. Together they use 80 percent of the world's oil. The world's five biggest consumers of oil—the United States, the Soviet Union, Japan, West Germany and France, in that order—are also among the world's most industrialized nations. They consume a total of nearly 38 million barrels a day, 58 percent of the world's total.

Americans use more energy than do any other people. Although we constitute only 6 percent of the world's population, we consume more than 30 percent of the world's energy production. Europeans, who enjoy a similar standard of living, use 2/3 less energy per person than we use.

Europeans and Japanese often point to American dependence on the automobile as the primary cause of energy waste. In North America production of motor gasoline accounts for 42.9 percent of total refinery output, whereas in any other region of the world, motor gasoline production does not exceed 20 percent. There are several reasons for this difference. In Europe and Japan the price of gasoline is often double or triple the price in the United States. Mass transit and inter-city passenger rail systems are heavily subsidized, and trains are famous for being clean, inexpensive, fast and on time — hardly the reputation of American trains.

The average person in many Third World countries uses less oil, gas and electricity in an entire year than an American consumes in a single day. Americans use 1,000 times as much commercial energy as the Nepalese and 400 times as much as the Ethiopians. Even if you take into account energy sources that people gather themselves, such as firewood, India's annual total energy consumption per person is still not quite 3 percent of ours.

To emerge from the poverty in which they now live, developing nations will need to use more energy. The dilemma of the Third World, however, is that most developing nations lack energy resources—imported or domestic—to build an industrial base, create jobs and export goods and services. And without the revenues of a sound and healthy economy, those nations are unlikely to develop their own energy resources or be able to absorb the cost of additional energy imports.

Bringing electricity to villages, for example, is a tremendous undertaking for most countries. The World Bank estimates that in 1975 only about 12 percent of the rural population of developing countries lived in villages or farms served by electricity. Even these "electrified" villages often had only a few buildings with electricity. In general, few families can afford to purchase electricity, even when it is heavily subsidized. And even if a family can afford the subsidized energy, it cannot afford the light fixtures, stoves, pumps or machinery to use it.

Although Third World countries survived the sudden quadrupling of international petroleum prices in 1973-74 better than feared, the United Nations officially proclaimed 45 of them to be "most seriously affected" by the price rise and the resulting recession. Industrialized nations, on the other hand, were able to respond to the rise in oil prices with increased conservation. Even the United States has decreased consumption and imports every year since 1977. But Third World nations must increase their energy imports in order to improve their economies.

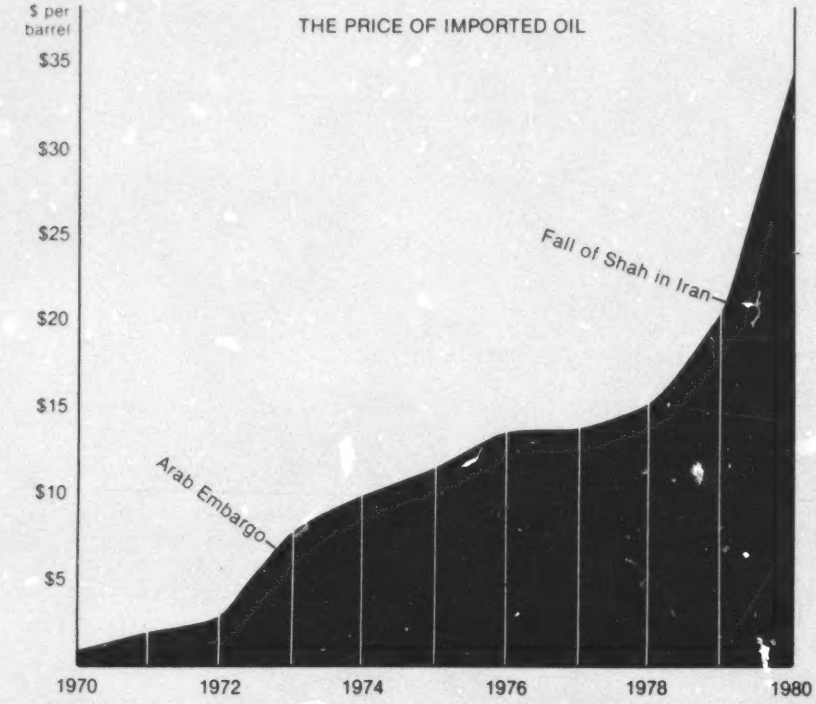
Oil-importing developing countries are expected to increase their import demand from the present 3.1 million barrels of oil per day to more than twice that by the turn of the century. By then their share of global energy consumption will rise to at least 30 percent. It is likely that developing countries will demand more oil than will be saved by industrial nations' efforts at conservation. Because of this projected imbalance, OPEC nations will probably retain their economic and political power at least over the majority of the world's nations: the Third World.

The Geopolitics of Energy

Much of the world's oil flows out of the Persian Gulf region of the Middle East. Nearly 20 million barrels of oil per day are exported from Persian Gulf ports in Iran, Iraq, Saudi Arabia, Kuwait and the United Arab Emirates. Some of the oil is transported by pipeline through Syria to the Mediterranean Sea. However, most of the oil is loaded into huge 100,000 ton oil tankers that must pass through the narrow, 23 mile-wide Strait of Hormuz before heading for Europe, Japan and North America.

The Persian Gulf states have amassed a fortune from their oil exports. The average per capita income in Kuwait, for example, is double that in the United States. But the area is probably the most politically volatile in the world. Revolution and war constantly threaten the security of the region.

In 1973 the Yom Kippur War broke out between Israel and a number of Arab states. OPEC declared that oil would not be sold to the United States, the Netherlands or any other



country that supported Israel during the Yom Kippur War. In 1979 Moslem extremists overthrew the Shah of Iran, and then in 1980 Iraq invaded Iran, taking major oil fields along its border. Each side damaged or destroyed the other's oil refineries. The Iranian revolution and the Iran-Iraq war have been blamed for creating oil shortages and higher prices.

These Middle East squabbles often bring America's interests into conflict with each other. Although the American position in the Middle East is to firmly support Israel, the United States also seeks to stabilize the region and ensure a steady flow of oil to itself and to its allies. Since 1973 the United States has acted as the primary arbitrator of the Arab-Israeli dispute.

American policy in the Persian Gulf, as declared in the Carter doctrine (and as maintained by President Reagan), is to defend Arab oil fields and oil tankers from attack. One potential threat to the oil flow is the Soviet Union. The Carter administration reacted to the 1979 Soviet invasion of Afghanistan by sending two aircraft carrier task forces to the region, and by announcing plans to develop a Rapid Deployment Force that would be sent to the region in an emergency. The Reagan administration reaffirmed its commitment to defend the oil fields from a Soviet attack by selling Saudi Arabia advanced military equipment. This included top-secret air-to-air missiles and five Advanced Warning and Control System aircraft (AWACS), the most advanced airplane in our arsenal, capable of detecting enemy air and sea movements early enough to send airplanes to counter an attack.

Global Energy in the Future

OPEC—Despite appearances, the oil-producing nations are interdependent with oil-consuming nations. Oil-producing nations, especially in the Middle East, import nearly all of their food and finished goods—like televisions, cars and refrigerators—from the United States, Europe and Japan. They also import billions of dollars' worth of sophisticated weapons, and advanced technology to build industrial plants, refineries and public buildings.

Oil producers are also dependent on oil consumers to buy their products. Oil producers may eventually raise prices to a point where other forms of energy—solar, gasohol, tidal, wind, liquefied coal or synfuels—will become more attractive energy sources than oil. If oil consumers were to begin a transition to other energy sources, world demand for oil would decrease. This would possibly spur dramatic decreases in the price of oil, and certainly would cause tremendous revenue losses for oil producers. Many oil-producing countries are preparing for the day when oil becomes a secondary source of energy by building nuclear reactors and by investing oil wealth in a variety of enterprises.

The Soviet Union—Russia seems to be self-sufficient in energy, and appears to have enough left over to export some to its allies. The Soviets, however, suffer from a serious problem of logistics: Although they have huge reserves of oil and natural gas, they lack modern drilling and pumping equipment needed to remove sufficient amounts of oil from the ground. Most modern oil drilling and pumping equipment is built in the United States, which ended sales to Russia after the Soviet invasion of Afghanistan.

The Soviet logistic problem leads to speculation that the Soviet Union soon may import its oil. This could give the Arab oil-exporting countries power over the Soviets, something they have never held before. Or it could lead the Soviets to overthrow present Arab governments and install leaders who would give price breaks to the Soviet Union.

The Third World—For a long time the Third World has neglected comprehensive energy planning. However, some countries have begun vigorous programs to develop domestic fossil fuels, to develop and install substitutes for oil, and, in a small but growing number of countries, to use energy more efficiently. For example, Brazil leads the rest of the world in research and development of ethanol, and India and China are actively exploring other uses of biomass energy. In at least 50 countries there are small-scale projects for developing renewable energy.

Nevertheless, consumption of oil and other fossil fuels in the Third World will certainly increase as the population grows and industry develops. Traditional forms of energy for the Third World, such as firewood and animal power, will surely play a smaller role than they have in the past, in part because of the serious decline in the availability of these traditional energy sources, especially firewood.

Some energy analysts have urged these nations to develop renewable

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resources, but unfortunately most Third World countries do not know whether (or how) new renewable technologies can be applied to their countries. Other scholars have urged industrial nations to search for energy in underdeveloped countries. If energy resources were found, these nations would be able to modernize and stabilize their economies, and would therefore compete less with developed countries for dwindling energy resources.

Industrialized World

Europe and Japan have always conserved more of their energy supply than we have since they lack significant energy resources of their own. In the future, they are expected to stress further conservation, maintenance of good relations with Arab oil suppliers, and imports of alternative energy sources.

Imports of coal from the United States have already broken records, and are expected to increase as the United States builds new coal port facilities. Imports of natural gas, however, may come from another direction. West Germany has agreed with the Soviet Union to buy $15 billion worth of natural gas. This deal has caused great controversy. Critics charge that importing large amounts of natural gas from Russia would leave the Germans open to political blackmail; others contend that the deal should increase interdependence between East and West and therefore decrease tensions.

In addition to importing coal and natural gas, European countries are turning to nuclear energy. France leads this trend, in part because the French have expressed less opposition to nuclear power than other nationalities have. Nuclear power is being developed less rapidly in other countries, most notably Japan. The only victim of the atomic bomb, Japan is especially reluctant to use nuclear energy.

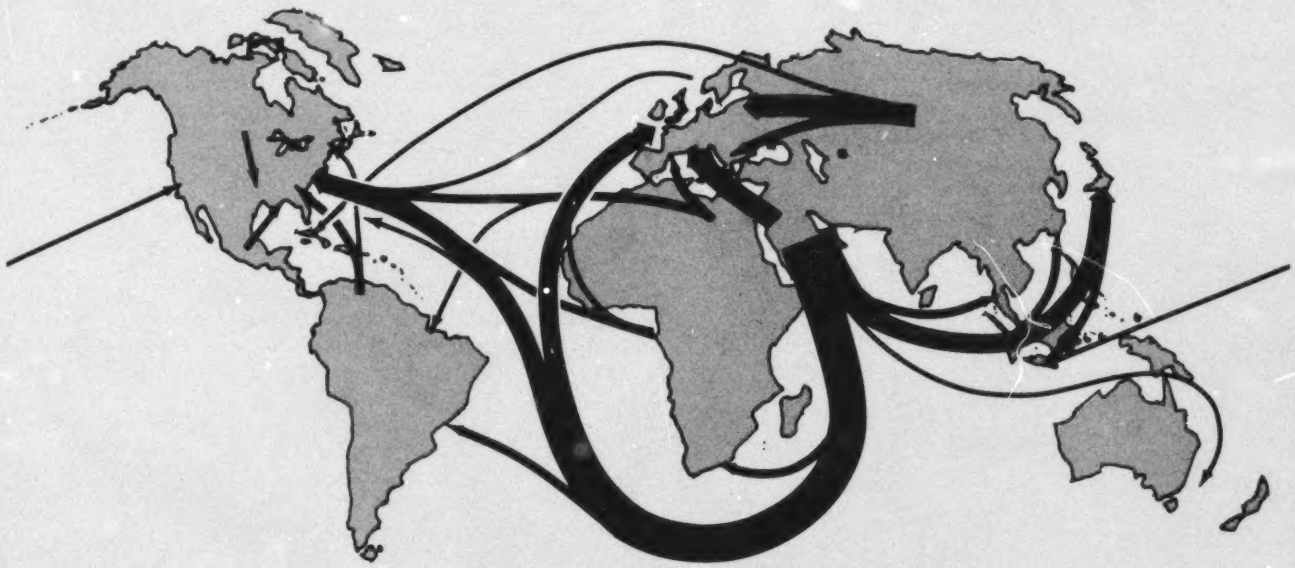
The United States

The United States is also preparing for the day the oil will run out. In 1980 there was a brief flurry of activity by the federal government to encourage the development of new energy resources, especially solar energy and synthetic fuels, and to expand output of traditional energy sources: to encourage more domestic drilling of oil and natural gas and to expand coal output.

America is also committed to keeping oil flowing from the Middle East to the United States and its allies. To back up that commitment, the United States maintains at least one aircraft carrier task force in the Indian Ocean near the Persian Gulf oil-producing region, and is trying to establish bases in the region to station troops and equipment.

Interdependence

Energy connects all nations in a web of interdependence. Energy producers and consumers depend on one another. The Europeans are dependent on American coal and Middle East oil. Arab oil producers are dependent on a steady flow of money from their customers to pay for their ambitious national development projects and to import food and technology from the West. The Soviets are finding their energy supplies cannot be tapped without help from the non-communist world. And the Third World depends on the oil producers for energy and on the industrial nations for development assistance. For all countries to achieve their national economic goals, cooperation must prevail over conflict. For U.S. policymakers the key question is: To what degree should global concerns affect U.S. energy policy?



INTERNATIONAL CRUDE OIL FLOW 1979

Points of View

The Dangers of Energy Dependence

Senator Pete V. Domenici (R-NM)

Senator Domenici, a member of the Senate Energy Committee, made these comments during the debate on the Synthetic Fuels Corporation, November 5, 1979.

This country of ours today is on its knees with both hands tied because it is dependent upon 8 to 9 million barrels of crude oil a day. We are on our knees, tied, strangling at the mercy of a cartel.

One would think that a country in that position must be bankrupt in terms of resources, would one not? Well, let me tell you how bankrupt we are. This country has 700 billion barrels of oil potential from shale — not millions, billions. And we are at the mercy of a cartel monopoly for 8 million barrels of crude oil. Let me repeat that we have 700 billion barrels of crude oil potential from just shale oil. That is one item.

We have 300 years' worth of coal, if coal were used for every bit of our energy needs. Listen again: We are on our knees because we cannot produce 8 million barrels of oil a day, and we have coal, 300 years' worth of coal, not in Arabia, not in Kuwait, not in Venezuela, not in Canada, but in America, the USA.

Third, we have 30 billion barrels of oil potential from tar sands. I have just taken three resources, and I am trying to make the point for America and for this Senate that "business as usual" has put us in this position where we have an abundance but are bankrupt; where we have an abundance but are totally dependent; where we have an abundance, but those who know of our vulnerability wake up every morning in a cold sweat, wondering, "When will somebody embargo America again."

We have seen one embargo. Now what approach is the cartel taking? A new scheme: There will be no embargo, but less oil will be produced by the cartel countries at a higher price. Less at a higher price, the exact opposite of enterprise economics. When are we going to learn that enterprise economics is not totally relevant today, when the cartel says, "less at higher prices," but our whole theory has been that higher prices should produce more?

The Need for International Cooperation

Senator Bill Bradley (D-NJ)

Senator Bradley, a member of the Senate Energy Committee, issued this statement November 20, 1980.

As long as the United States continues to depend on unstable Persian Gulf sources for about 25 percent of its oil supply, our national and economic security will be in jeopardy. Ethnic, religious or territorial conflicts in the area are almost certain to flare up again before long. Future confrontations could have more impact, since many countries in the region now have large arsenals of sophisticated weapons, and some apparently are acquiring a nuclear capability as well.

Despite these events and obvious risks, the United States has chosen to commit our limited resources to costly programs aimed at the remote goal of energy independence. Instead, we should be focusing on emergency preparedness measures.

Above all, that means America's leaders must convince our citizens — in realistic, but not alarming, ways — that we may find on any given day that oil has stopped coming out of the Persian Gulf region. Were that to happen, one-quarter of the oil Americans depend on for their daily needs would be missing.

Earlier this year we made some progress when Congress ordered the government to resume filling our Strategic Petroleum Reserve at a minimum rate of 36 million barrels a year. A country without an adequate stockpile when a cutoff occurs is similar to a worker who has no savings or unemployment insurance when he or she loses a job. Both the nation and the worker quickly become destitute.

However, much more needs to be done. We must rapidly develop alternatives to rationing for allocating scarce supplies during an emergency, and we must find a way to stop the enormous flow of wealth from consumers to producers when oil is cut off and prices skyrocket.

Beyond that, it is apparent that the United States cannot deal effectively with the oil security problem in isolation. Because Japan and Western Europe will continue to depend on insecure foreign oil, our economic and military interdependence with them would keep us strategically vulnerable to supply disruptions even if we were willing to pay the high price of energy independence.

In the final analysis, the United States must demonstrate consistent leadership in a sound international oil security policy. To do that, we must persuade our allies and our friends in the Middle East and the Third World that we have the political will to reduce our own vulnerability so that we can assist them if necessary.

Glossary

acid rain—phenomenon caused by sulfates and nitrates combining with moisture in the upper atmosphere. Acid rain is blamed for killing organisms in many northeast lakes.
alternative sources—types of energy that can be substituted for traditional sources. Synthetic fuels and renewable resources are alternative sources of energy.
barrel—42 gallons. A measure of oil.
barrel oil equivalent—a measure of energy equal to the energy in one barrel of oil.
biomass—plant matter of any form. Biomass, a renewable resource, is essentially a form of stored solar energy.
breeder reactor—type of reactor that actually creates more fuel than it consumes.
Btu—British thermal unit. A standard measure of energy based on the amount of energy needed to raise the temperature of a pound of water one degree. For most purposes Btus are measured in quadrillions, 1,000 trillion.
cartel—a combination of countries intended to exercise monopoly-like control over prices. OPEC is a cartel formed to control the price of oil.
chain reaction—series of reactions in which a uranium nucleus is split, releasing neutrons traveling at high speeds, which, in turn, split other uranium nuclei.
cogeneration—using waste heat or steam from one industrial application—usually electricity generation—for another industrial application.
conservation—saving nonrenewable resources by eliminating unnecessary use or improving efficiency.
control rods—rods composed of neutron-absorbing material located in the nuclear reactor core. The rods can be raised to permit a chain reaction or lowered to stop one.
decommissioning—disassembling a nuclear power plant. Most nuclear power plants have only a 30-year life expectancy, after which they must be decommissioned.
decontrol—removal of price constraints from energy sources, allowing the market to determine price levels.
embargo—a stoppage of exports. OPEC placed an embargo on oil shipments to supporters of Israel during the 1973-74 Yom Kippur War.
enhanced recovery—techniques that extract a higher percentage of oil from the ground than do conventional techniques. (The average well extracts only 32 percent of the oil.)
enrichment—the process by which uranium is prepared for use as nuclear fuel.
environmental regulation—rules established by the government that are intended to limit the adverse environmental impact of industrial and commercial activity.
fossil fuels—energy sources derived from decayed plant matter.
free market—economic activity determined by the forces of supply and demand and not by actions of government.
fuel rods—narrow cylinders that contain pellets of uranium fuel. Fuel rods are interspersed with control rods in the core of a nuclear reactor.
gasohol—a mixture of gasoline and alcohol. Alcohol is commonly distilled from crop wastes or from other forms of biomass.
geothermal—heat produced deep in the earth by radioactive decay.
government intervention--actions taken by the government to regulate the operation of the market.
half-life—length of time required for one-half of a radioactive substance to decay (become non-radioactive).
hydroelectric—electric energy generated by the power of falling water.
nitrogen oxides—pollutants emitted by burning coal.
nuclear fission—splitting atomic nuclei, often the nuclei of uranium atoms, to release energy. Nuclear fission is a technique used in nuclear power plants.
nuclear fusion—combining atomic nuclei, especially those of hydrogen atoms, to release energy. Nuclear fusion provides the sun with its energy. Its use on earth is currently in the research and development stage.
nuclear reactor—core of a nuclear power plant in which nuclear fission takes place.
OPEC (Organization of Petroleum Exporting Countries)—organization composed of major oil exporting countries that operate as a cartel to set world oil prices to their benefit.
photovoltaic cell—device made of a semiconductor such as silicon that produces small amounts of electricity from solar energy.
plutonium—radioactive material produced as a by-product of nuclear fission that is useful for making nuclear weapons. Plutonium has an exceptionally long half-life, and for this reason is quite dangerous.
process heat/steam—heat or steam used directly by industry (as opposed to being used to produce electricity).
quad—shortened version of one quadrillion Btus. (See Btu.)
radioactivity—emission of harmful subatomic particles. High levels of radioactivity can cause death; lower levels can cause cancer or other harmful effects.
renewable resources—energy sources that originate with the sun, the moon's gravitational forces, or the earth's internally generated heat, and that will not run out, such as solar, wind, biomass, tidal and geothermal energy.
reprocessing—extracting waste materials from spent nuclear fuel in order to reuse the fuel.
research and development (R&D)—the basic investigative, creative, and experimental work that results in new technology.
retorting—the process by which oil is extracted from oil shale. The shale is first crushed and then heated to remove the oil it contains.
solar, active—solar collection devices that concentrate and distribute solar energy for heating or cooling purposes, or that convert solar energy to electricity.
solar, passive—solar collection devices that have no moving parts, and that use solar energy directly to heat space or water.
strip mining (surface mining)—method of extracting coal or oil shale used when deposits lie close to the surface. In strip mining, topsoil is stripped away to expose the deposit.
sulfur dioxide—pollutant emitted by burning coal. Sulfur dioxide is one of the main causes of acid rain.
synthetic fuels (synfuels)—energy sources produced by converting one energy form into another. The most common synfuels are oil and gas from coal, oil from oil shale, and oil from tar sands.
unconventional gas—natural gas found in such unusual locations as coal seams and shale formations.
underground mining—method of extracting coal primarily used when deposits lie deep below the surface. This method is associated with mining accidents and black lung disease.
uranium—material used as fuel in nuclear power plants. Uranium normally occurs as U-238 with trace amounts of U-235. It must be enriched to increase the percentage of U-235 before it can be used.
windfall profits—profits resulting from rapid price decontrol.

The Close Up Foundation

The Close Up Foundation is a non-profit, multipartisan organization dedicated to encouraging the involvement of young people in the democratic process. The Close Up Foundation has no affiliation with any branch of government, political party or interest group. The Foundation's board of advisors includes representatives of both political parties and many political viewpoints.

The Close Up Foundation runs a Washington seminar program that brings high school students and their teachers to the nation's capital for a week-long, on-site learning experience. In the 1981-82 school year, approximately 14,000 young people and educators will participate in the Close Up Washington experience.

In addition to the Close Up Washington program, the Foundation publishes resource books and materials about American government, including *Perspectives*, a book of original articles written by policy makers and other knowledgeable insiders, and *Current Issues*, readable and balanced summaries of the major issues of the day. Close Up also televises four series of Washington-based seminars for use in classrooms across the country. In addition the Close Up Foundation sponsors local Close Up programs for studying state and local government, parallel programs for international students and handicapped individuals during the regular sessions, and a teacher program designed to complement the student experience.

For more information about these or other Foundation programs, contact Close Up Foundation, 1235 Jefferson Davis Highway, Arlington, Virginia 22202.